Electromagnetic Engineering (EC 21006)
T U T O R I A L - VIII

REFLECTION OF Plane WAVES

1. The plane $z = 0$ defines the boundary between two dielectrics. For $z < 0, \varepsilon_{r1} = 5, \epsilon''_{r1} = 0$, and $\mu_1 = \mu_0$. For $z > 0, \epsilon'_{r2} = 3, \epsilon''_{r2} = 0$,and $\mu_2 = \mu_0$. Let $\boldsymbol{E}^+_{x1} = 200\cos(\omega t - 15z)$ V/m; find (a) ω; (b) $\langle S_1^+ \rangle$; (c) $\langle S_1^- \rangle$; (d) $\langle S_2^+ \rangle$.
2. A 10 MHz uniform plane wave having an initial average power density of $5W/m^2$ is normally incident from free space onto the surface of a lossy material in which $\epsilon''_2/\epsilon'_2 = 0.05, \epsilon'_{r2} = 5$,and $\mu_2 = \mu_0$. Calculate the distant into the lossy medium at which the transmitted wave power density is down by 10 dB from the initial $5W/m^2$.
3. The region $z < 0$ is characterized by $\epsilon'_r = \mu_r = 1$ and $\epsilon''_r = 0$. The total **E** field here is given as the sum of two plane waves, $\boldsymbol{E}_s = 150e^{-j10z}\boldsymbol{a}_x + (50\angle 20^0)e^{j10z}\boldsymbol{a}_x$ V/m. (a) what is the operating frequency? (b) specify the intrinsic impedance of the region $z > 0$ that would provide the appropriate reflected wave; (c) at what value of $z, -10\ cm < z < 0$, is the total electric field intensity a maximum amplitude?
4. Region 1, $z < 0$, and region 2, $z > 0$ are described by the following parameters: $\epsilon'_1 = 100pF/m$, $\mu_1 = 25\ \mu H/m$, $\epsilon''_1 = 0, \epsilon'_2 = 200pF/m$, $\mu_2 = 50\mu H/m$, and $\epsilon''_2/\epsilon'_2 = 0.5$. If $\boldsymbol{E}^+_1 = 5e^{-\alpha_1 z}\cos(4\times 10^9 t - \beta_1 z)\boldsymbol{a}_x$ V/m, find: (a) α_1 ; (b) β_1; (c) $\langle S_1^+ \rangle$; (d) $\langle S_1^- \rangle$; (e) $\langle S_2^+ \rangle$.
5. Region 1, $z < 0$, and region 2, $z > 0$, are both perfect dielectrics ($\mu = \mu_0, \epsilon'' = 0$). A uniform plane wave travelling in the $\boldsymbol{a}_z$ direction has a radian frequency of 3×10^{10} rad/s. Its wavelengths in the two regions are $\lambda_1 = 5cm$ and $\lambda_2 = 3cm$. What percentage of the energy incident on the boundary is : (a) reflected; (b) transmitted? (c) what is the standing wave ratio in region 1?
6. A 50 MHz uniform plane wave is normally incident from air onto the surface of a calm ocean. For seawater, $\sigma = 4\ S/m$ and $\epsilon'_r = 78$. (a)Determine the fractions of the incident power that are reflected and transmitted. (b) Quantitatively, how will these answers change (if at all) as the frequency is increased?
7. Consider these regions in which $\epsilon'' = 0$: region 1, $z < 0, \mu_1 = 4\mu H/m$, and $\epsilon'_1 = 100pF/m$; region 2, $0 < z < 6\ cm, \mu_2 = 2\mu H/m$, and $\epsilon'_2 = 25pF/m$; region 3, $z > 6\ cm, \mu_3 = \mu_1$, and $\epsilon'_3 = \epsilon'_1$. (a) what is the lowest frequency at which a uniform plane wave incident from region 1 onto the boundary at $z = 0$ will have no reflection? (b) If $f = 50\ MHz$, what will the standing wave ratio be in region 1?
8. A uniform plane wave is normally incident onto a slab of glass ($n = 1.45$) whose back surface is in contact with a perfect conductor. Determine the reflective phase shift at the front surface of the glass if the glass thickness is: (a) $\lambda/2$; (b) $\lambda/4$; (c) $\lambda/8$.